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Theory and Key Principles Series

Gas Chromatography (GC)

Session 1 – Introduction to Gas Chromatography

Theory & Key Principles Series – GC

– Introduction to Gas Chromatography

– GC Columns

– The Split/Splitless Inlet

– Advanced Liquid Injection Techniques

– Alternatives to Liquid Injection

– Choices of Detectors for GC

– Processing GC Data

– Maintenance & Troubleshooting

GCMS series to follow!

Introduction to gas chromatography

In this presentation:

- Welcome and introduction
- Principles of gas chromatography
- Uses of gas chromatography
- Hardware overview
- Carrier gas

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Welcome & Introduction

Introduction

Welcome to Shimadzu's Gas Chromatography Theory and Key Principles Series!

Series presenters

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Who are Shimadzu?

A Japanese company founded in 1875 by Genzo Shimadzu Sr.

One of the world's largest manufacturers of analytical equipment.

Business areas

Analytical Instruments

HPLC, UHPLC & SFC

LCMS

GC & GCMS

UV-vis

FTIR

ICP-MS & ICP-OES

Business areas

Testing and Measuring Instruments

High-speed Cameras

Balances

Testing Machines

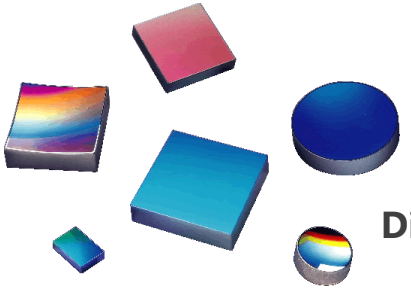
Aircraft Equipment

Air Management Systems

Medical Systems

PET Scanner for Breast Imaging

Industrial Equipment



Diffraction Gratings

Shimadzu UK

- Part of the European Shimadzu group, which has been in Germany for over 50 years.
- Present in the analytical and testing machines market in the UK for over 20 years.
- UK Centre of Excellence opened in 2006 to directly support our customers.
- Large research labs in Manchester, developing analytical instruments including mass spectrometry, surface analysis and software informatics since 1997.

Shimadzu European HQ

UK Centre of Excellence

Shimadzu Research Labs, UK

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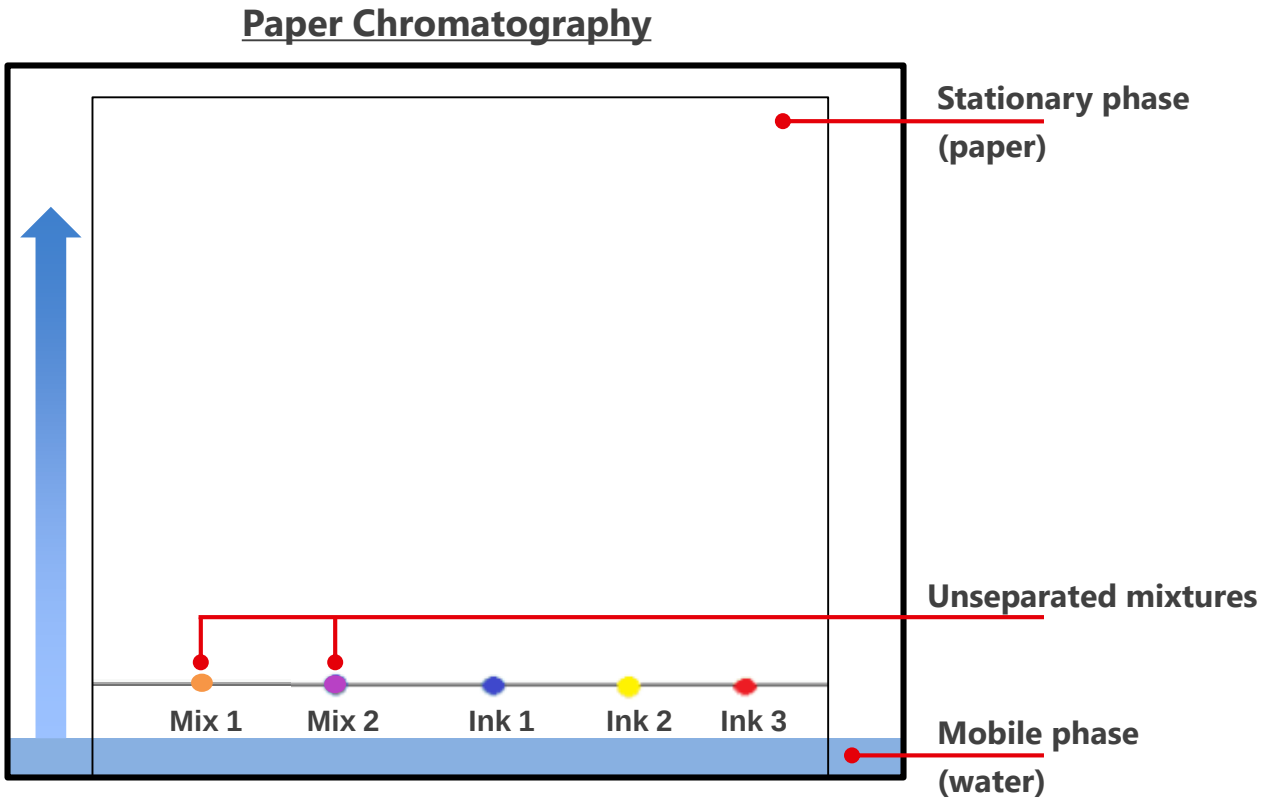
Principles of Gas Chromatography

What is chromatography?

*Chromatography is a technique for **separating a mixture of substances**.*

*It has a **mobile phase**, which the sample is dissolved in, or transported with, and a **stationary phase** that the sample travels on or through.*

*The different substances in the mixture have **different affinities for the stationary phase**, so spend more or less time adsorbed to its surface.*



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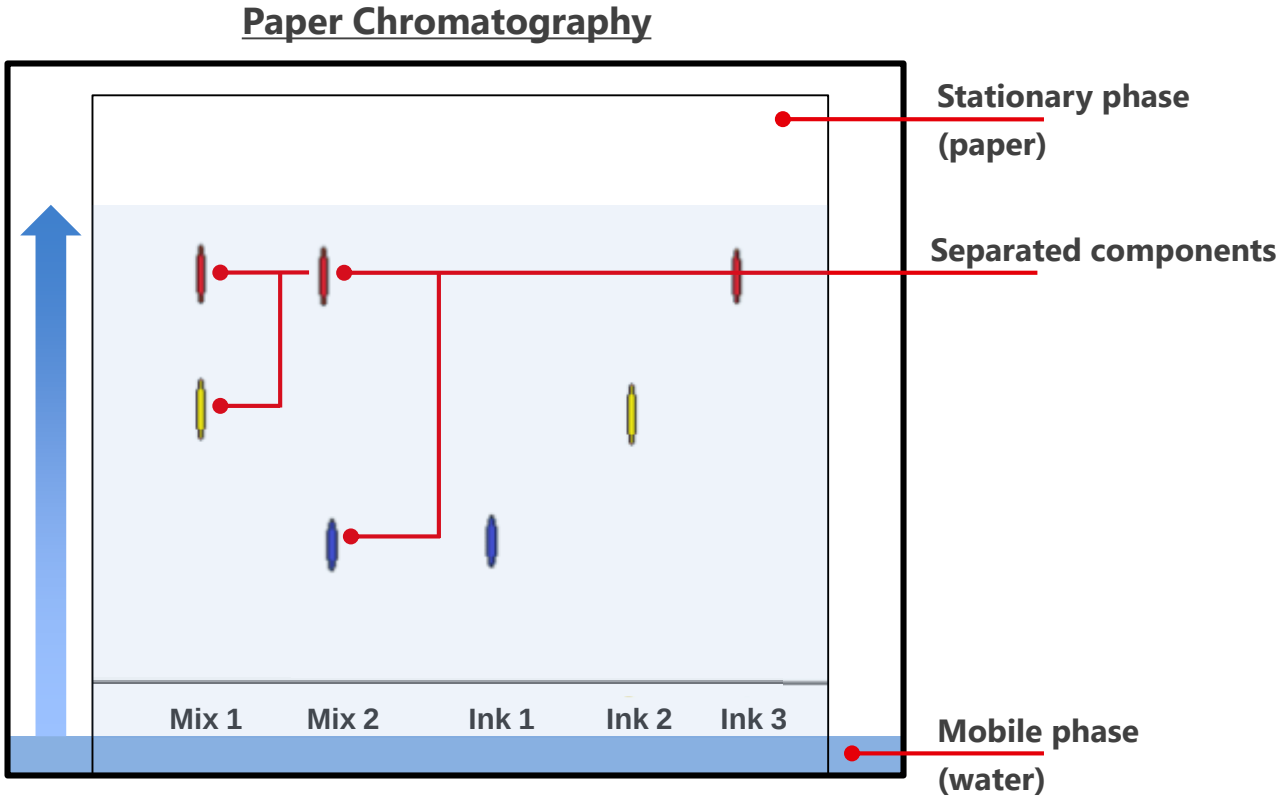


Examples of common chromatographic techniques

- **Paper chromatography (previous slide)**
- **Thin layer chromatography (TLC)**
  Good for simple mixtures
  - A thin film of material (silica) fixed to a surface - STATIONARY PHASE
  - A liquid (solvent) that flows up the dry adsorbent - MOBILE PHASE
  - As the mobile phase rises, it transports the sample. This moves with the mobile phase and separates out, based on the interaction with the silica stationary phase.
  - In optimal chromatography, these fractions would consist of single components from the sample mixture!
- **Liquid chromatography (LC)**
- **Ion chromatography (IC)**
- **Gas chromatography (GC)**

} **Shimadzu offers equipment for all these techniques**

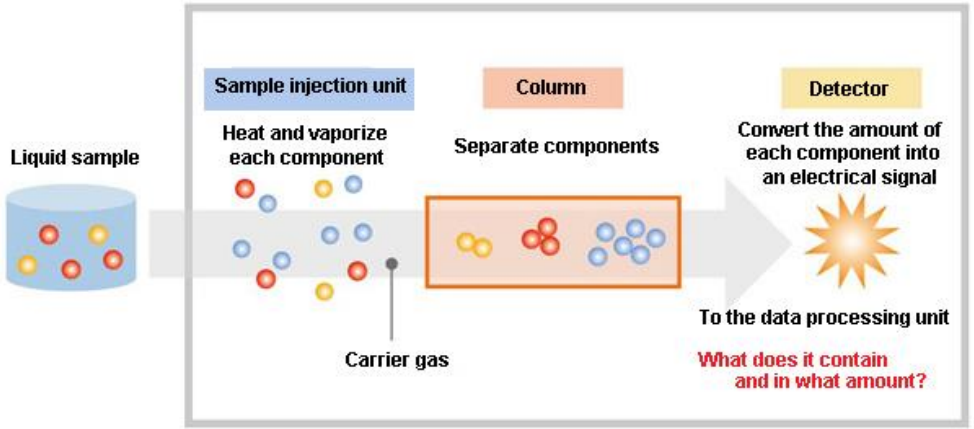
What is gas chromatography (GC)?

Gas chromatography is a technique…
performed using a **Gas Chromatograph**…
by a **Chromatographer**…
to generate a **Chromatogram.**

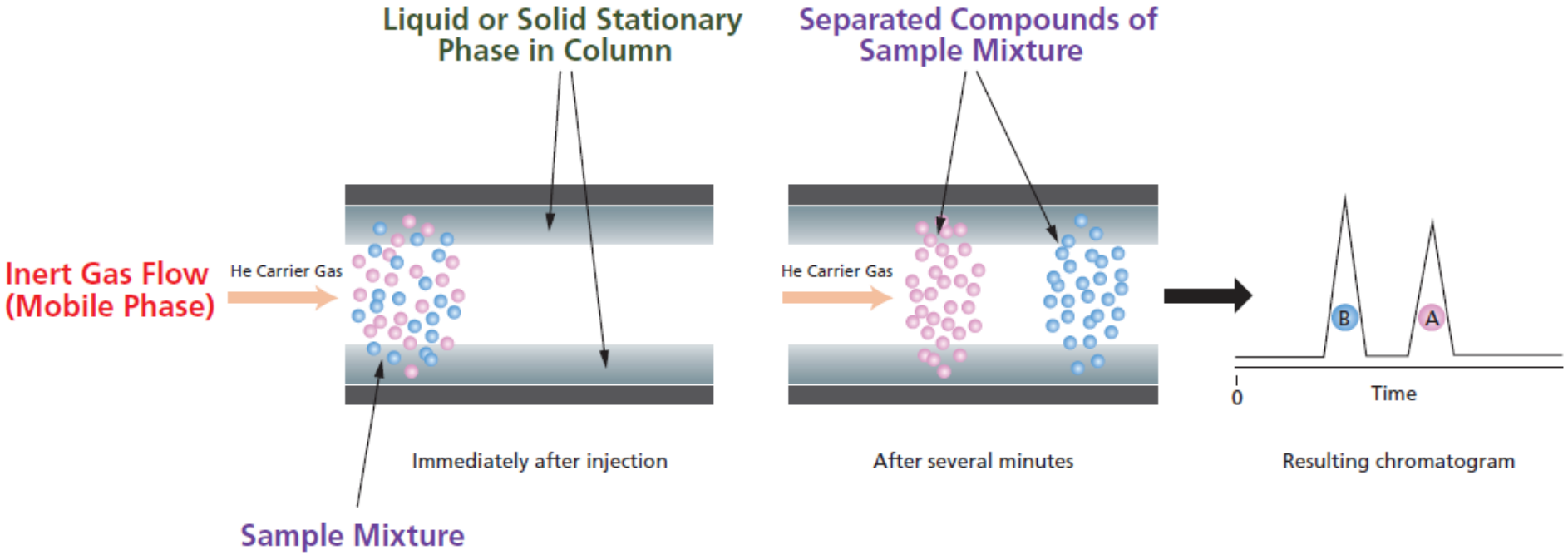
In gas chromatography:

- A viscous liquid or solid is fixed to a supporting, hollow tube (column) - STATIONARY PHASE
- A carrier gas flows through the tube, carrying the mixture - MOBILE PHASE

- In a simple system:



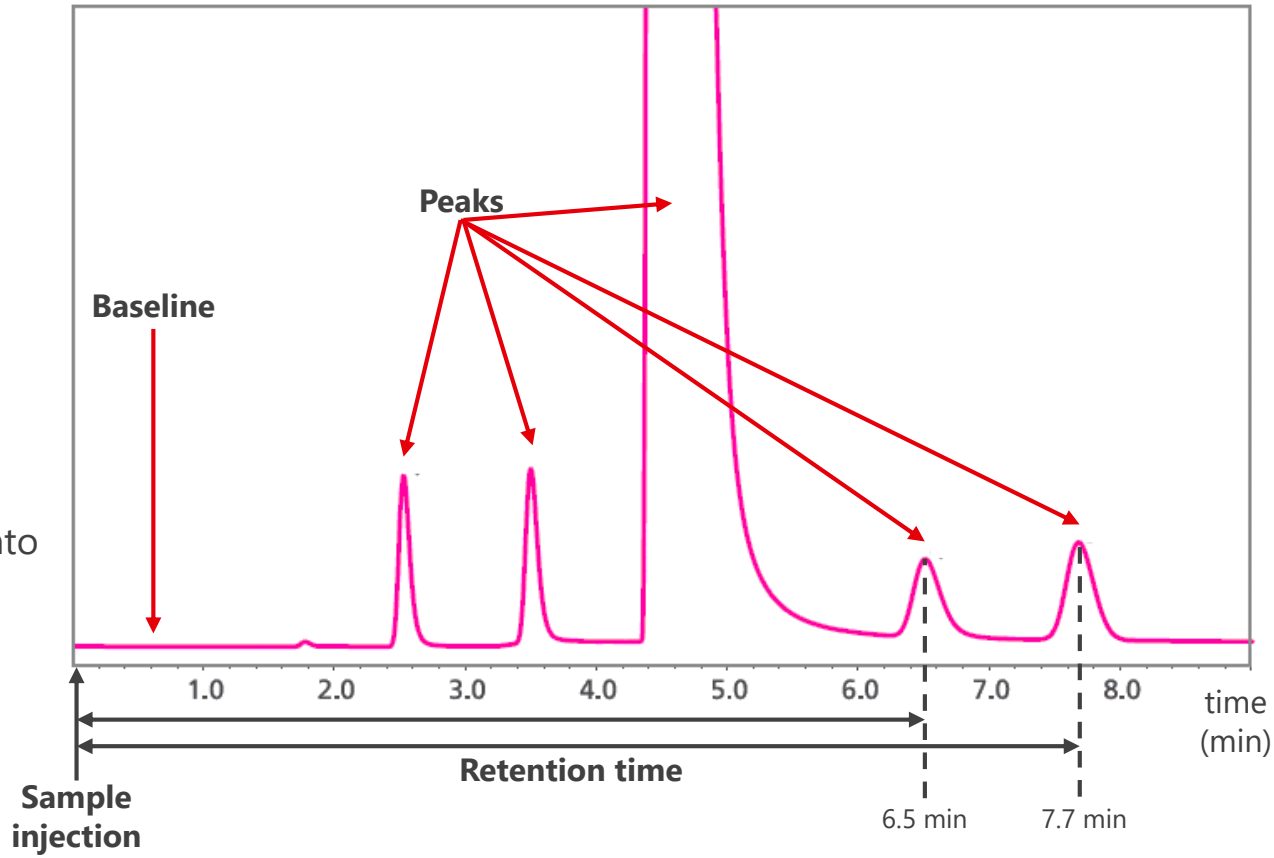
What is gas chromatography?



What is gas chromatography?

The chromatogram shows signal intensity on the y-axis and **retention time** (mins) on the x-axis.

Retention time is the time between **sample injection** on the front of the column and a **component eluting** into the detector at the other end.



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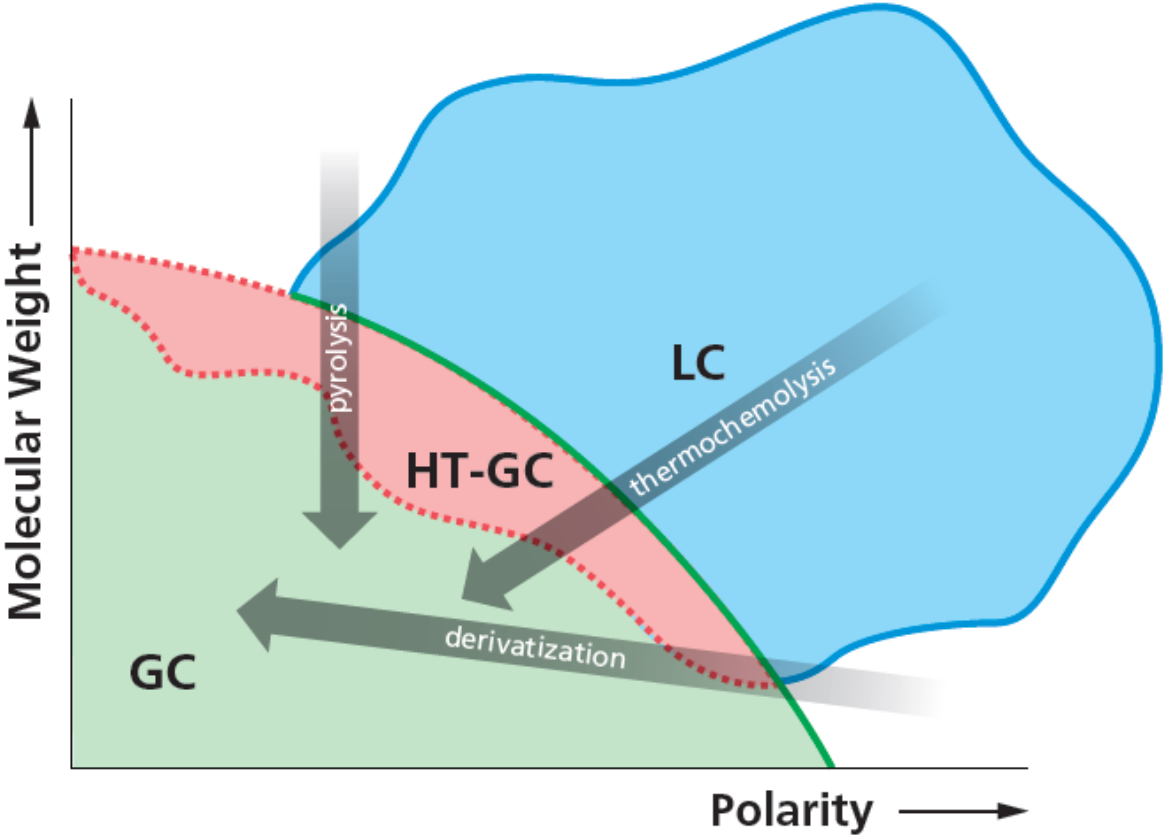
Uses of Gas Chromatography

What can GC be used for?



Typical applications

Flavor & Fragrance

Analysis of aromatics in perfume, wine and coffee

Flavor & Fragrance

Oil, Gas & Chemical

Oil, Gas & Chemical

Analysis of sulfur, inorganic gases & light hydrocarbons

Environmental Testing

Environmental Testing

Analysis of volatile environmental pollutants

Pharmaceuticals

Impurities & residual solvent analysis

Pharmaceuticals

Forensic Toxicology

Forensic Toxicology

Steroid and drug analysis

Food & Beverage

Analysis of pesticides, additives & contaminants

Food & Beverage

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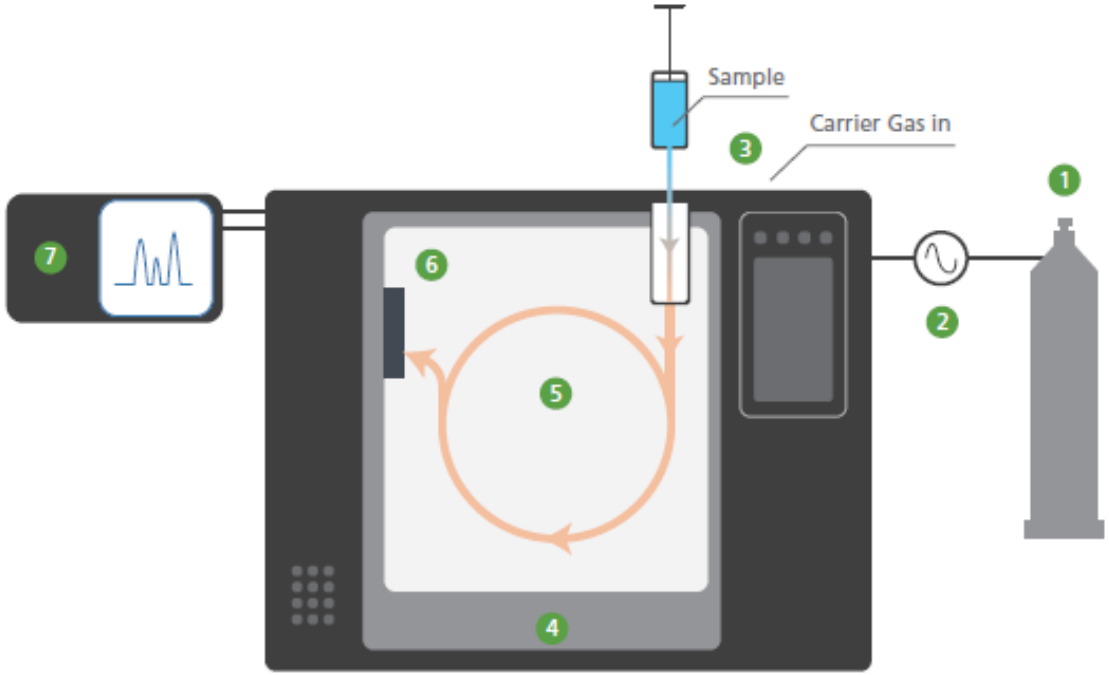
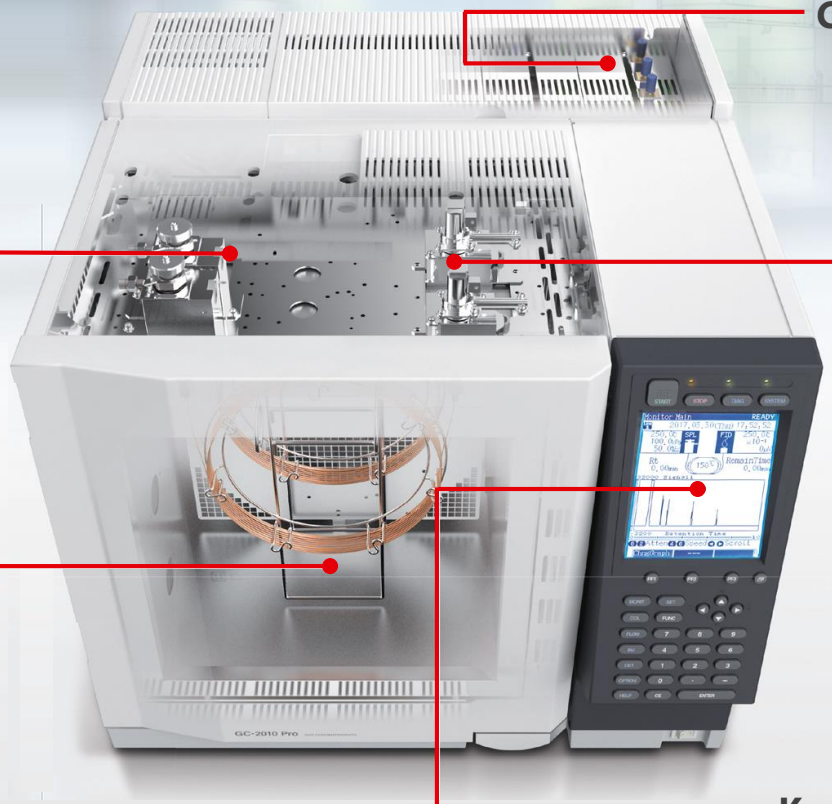
Hardware overview

Typical gas chromatograph



1. Carrier Gas (Gas Cylinders)
2. Flow Regulator
3. Injection Port
4. Column Oven (thermally-controlled)
5. Column
6. Detector
7. Computer and Output

Modern gas chromatograph



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Carrier gas

Carrier gas (mobile phase)

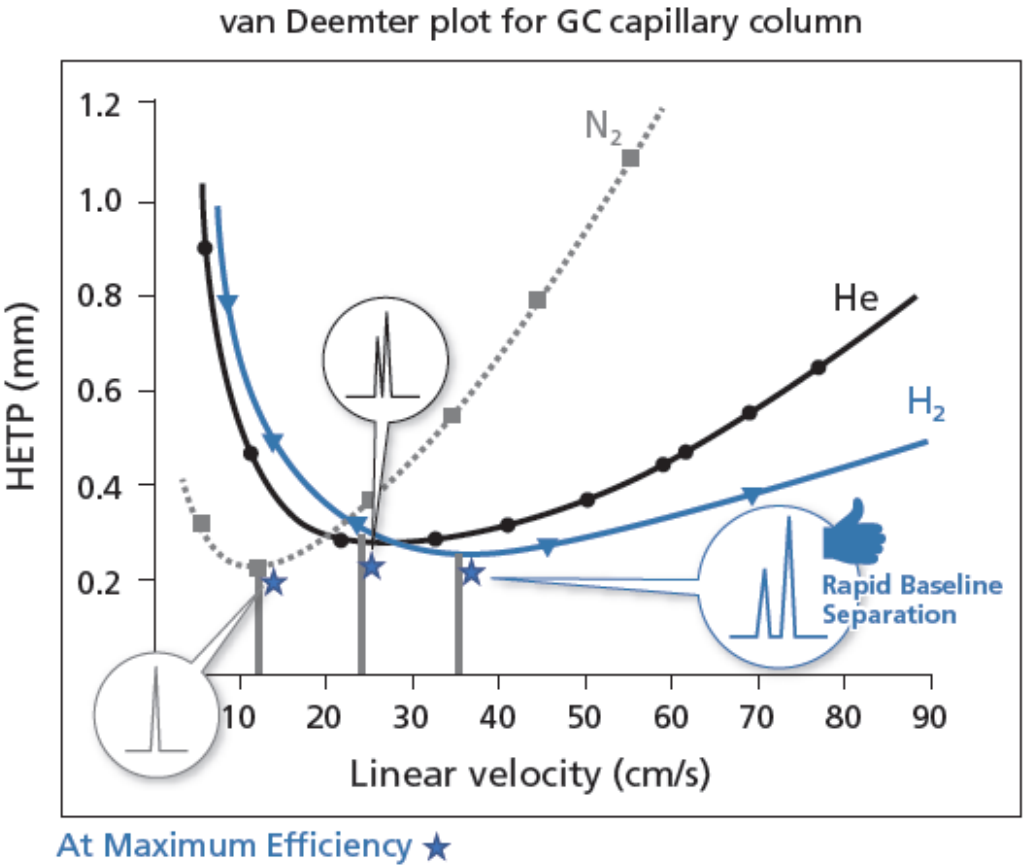
It must be **inert**, **extremely pure** and **completely dry**.

Typically this is helium, although hydrogen and nitrogen can also be used.

For normal GC applications, the required purity is typically 5.0 (99.999%) or above.
For high-sensitivity GCMS, 6.0 (99.9999%) is needed!

The gas must be pressurised with an output pressure typically between 500-900 kPa, using a regulator.

Carrier gas properties



HETP: Height equivalent to a theoretical plate (parameter that indicates the separation efficiency of a column)

Low HETP

Better resolution

Linear velocity: Average value of the speed of a carrier gas flowing in a column

Carrier gas properties

Carrier Gas	Pros	Cons
Hydrogen (H_2)	• High diffusivity and linear velocities • Gets good separation efficiencies • Short analysis and run time (results in cheap operational cost)	• Flammable • Not completely inert (e.g. reacts with some compounds at high temperature)
Helium (He)	• Inert (safe) and non-flammable • Gives high resolution	• Expensive, not easily available
Nitrogen (N_2)	• Cheap and easily available	• Not suited for use in temperature-programmed GC analysis • Long analysis and run time

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Summary

Summary

- **Gas chromatography is a common technique for analysing mixtures of volatile and semi-volatile compounds.**
  - It is suited to analysing light organics, but is not suitable for heavier compounds, metals or salts.

- **It separates using gas as a mobile phase and a column coated with a stationary phase.**

- **A GC system comprises of an:**
  - **High-purity gases** (mobile phase and for detectors to function)
  - **Injector** (to introduce the sample onto the column)
  - **Column** (to perform the separation)
  - **Column oven** (to control the separation and elution of compounds)
  - **Detector** (to detect the eluting components)
  - **Data system** (to process the signal from the detector)

- **The mobile phase is high-purity "carrier" gas** (typically helium, hydrogen or nitrogen)
- **The stationary phase is supported on a column**

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Next time

The next session will be on…

GC Columns

This will cover:

- *Different types of GC columns*
- *The different column dimensions and their relevance*
- *Column phases and polarity*
- *Temperature ranges for columns*

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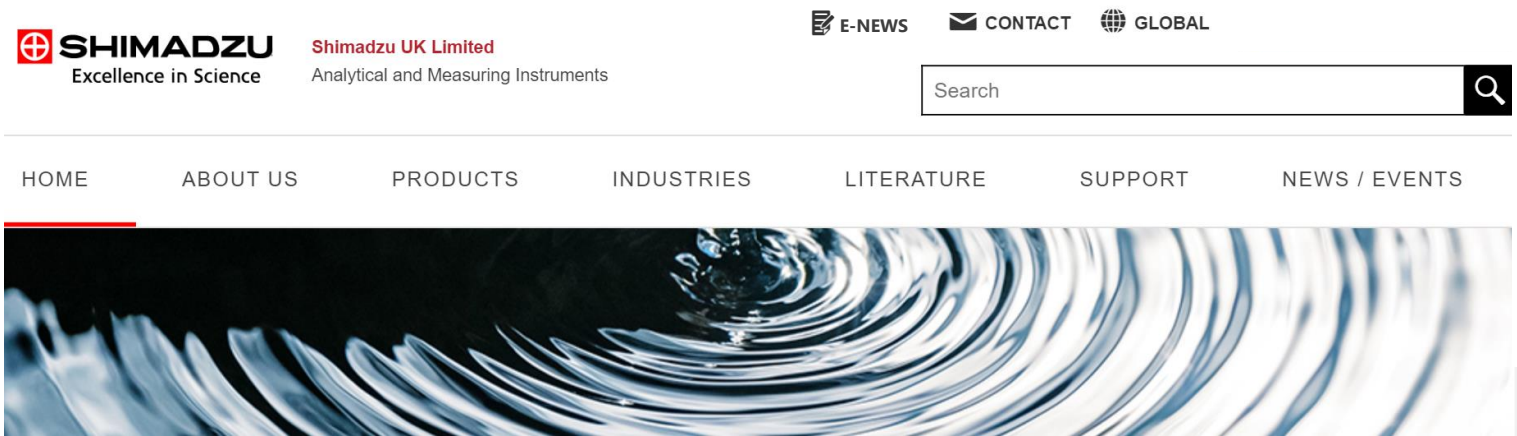

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